Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

GROWING WHEAT IN CALIFORNIA

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P. C. BERRYMAN

CALIFORNIA AGRICULTURAL
Experiment Station
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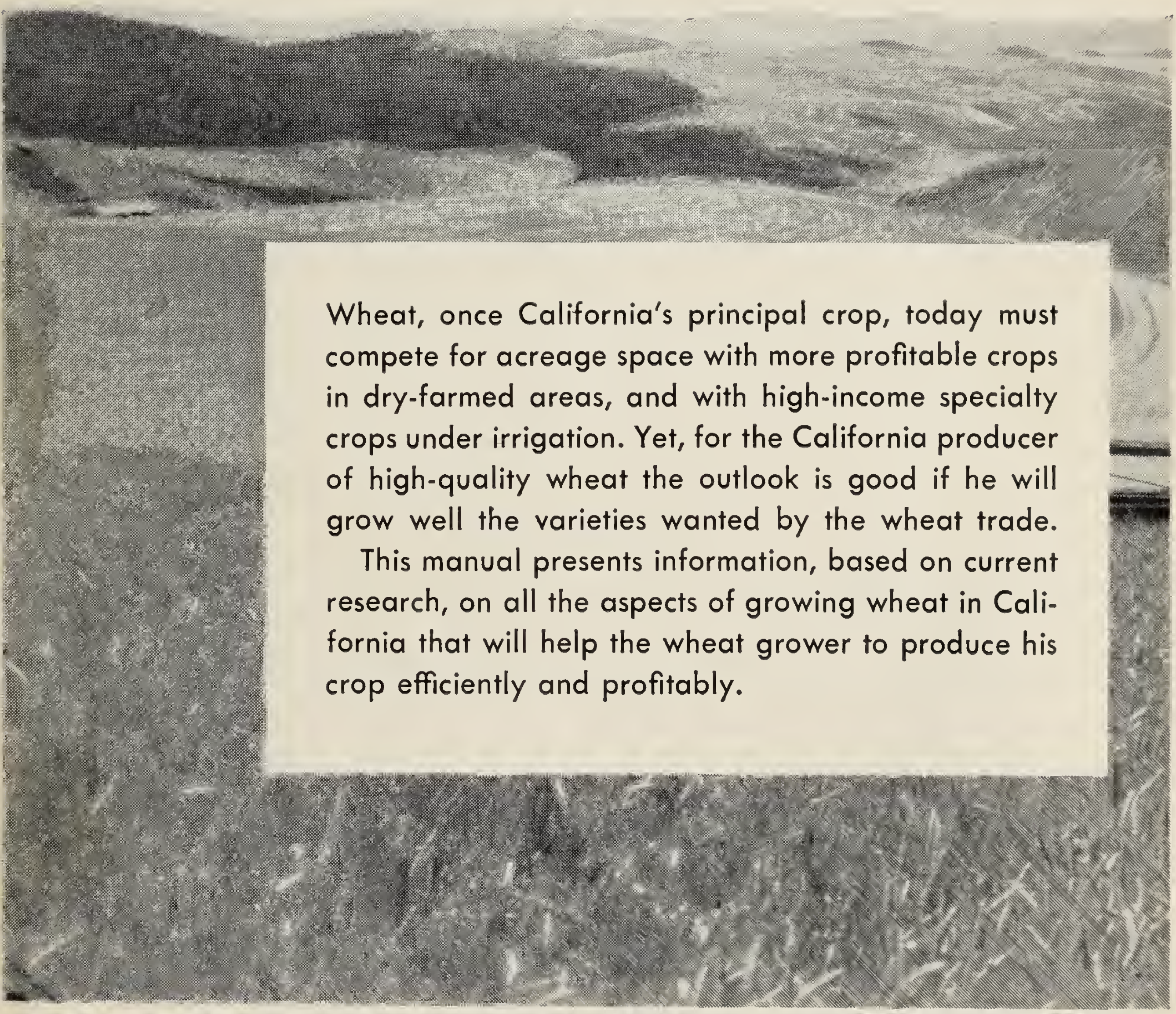
GROWING

WHEAT IN CALIFORNIA



Wheat, once California's principal crop, today must compete for acreage space with more profitable crops in dry-farmed areas, and with high-income specialty crops under irrigation. Yet, for the California producer of high-quality wheat the outlook is good if he will grow well the varieties wanted by the wheat trade.

This manual presents information, based on current research, on all the aspects of growing wheat in California that will help the wheat grower to produce his crop efficiently and profitably.

UNIVERSITY OF CALIFORNIA
DIVISION OF AGRICULTURAL SCIENCES
California Agricultural Experiment Station—Extension Service

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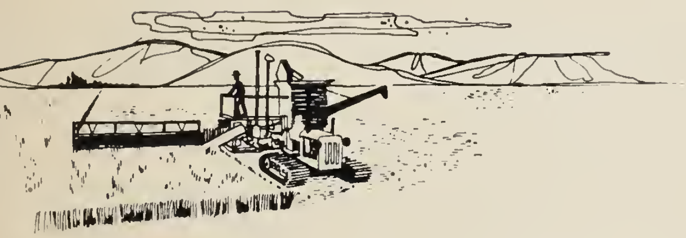
THIS MANUAL is one of a series published by the University of California College of Agriculture and sold for a charge which is based upon returning only a portion of the production cost. By this means it is possible to make available publications which, due to relatively high cost of production, or limited audience, would otherwise be beyond the scope of the College publishing program.

GROWING WHEAT IN CALIFORNIA

A High-quality Cereal Crop Used for Human Food and Livestock Feed



MILTON D. MILLER · C. W. SCHALLER · P. C. BERRYMAN

WHEAT CAN BE GROWN in all counties of California, but because of soil, climate, and economic forces commercial production is concentrated in eastern San Luis Obispo County, districts of the San Joaquin and Sacramento valleys and in Siskiyou County east of Yreka. Durum wheat for semolina is grown in the Tulelake Basin of Siskiyou and Modoc counties. High protein wheat for bread flour is produced mainly on dry-land under low-rainfall conditions. Wheat grown under moderate to high-rainfall or irrigation occasionally may be milled for flour, but because of lower quality is generally used for poultry and livestock feed.

Soil

Wheat is best adapted to fertile medium textured soils that are slowly, but completely drained. The silt and clay loams are preferred, but wheat also is grown successfully on either clay soils or fine sandy loams. Because it can withstand temporary soil water-logging, wheat is the most satisfactory winter-planted cereal to use in crop rotation with rice.

Moisture Requirements

Economic grain yields can be produced with 14 to 16 acre-inches of water available from rain or irrigation. If the soil is wet to an average depth of three feet in fallow fields at seeding time, satisfactory crop yields can be expected in low-rainfall, dry-farmed districts with annual rainfall of eight inches or more, well distributed from November through April. In dry-farmed districts where average annual rainfall is less than 14 inches, particularly if it is poorly distributed, the crop must be sown on fallow, or else irrigated.

Climate

Wheat is a cool-season crop. Spring wheat varieties, commonly grown in California, may survive mid-winter temperatures as low as 10°F or lower in the early stages of growth for short periods of several hours. Temperatures of 28°F to 33°F at heading may cause some ste-

rility in all or some portions of the seed heads (spikes). A light frost during the late stages of kernel filling usually stops further grain development, and results in indentations on the seed coat and shrivelled grain. True winter wheat varieties, with proper snow coverage, may withstand mid-winter temperatures as low as –25°F when in a hardened condition.

To avoid crop losses in districts subject to strong winds when the crop matures, plant shatter-resistant varieties. See page 6 and the table on pages 8–9 for information on varietal characteristics. Wheat grown in foggy, coastal areas may be so badly discolored that it can be sold commercially only as livestock and poultry feed.

CHOOSING VARIETY AND SEED

Uses of Wheat

Wheats grown in California have two major uses: for human food and for livestock, largely poultry, feed. Varieties used for human food are grouped, first, into the hard white wheats with high protein, used to mill flour for bread making; second, the soft white wheats with very low protein, used for family flours, cake, crackers, breakfast foods; and third, the durum types with high protein, used for the granular flour (semolina) in macaroni, spaghetti and other paste-type foods.

Wheat used for bread making must meet certain standards of kernel color, water absorption, loaf volume, and texture. Protein content is only one of the wheat-quality factors. As a rule, wheat shrunken by drought or disease so that its weight per measured bushel is less than 56 pounds will not give a satisfactory flour yield. Variety, environment and soil influence that complex of chemical and physical properties called "quality." High protein content generally produces a better loaf of bread, and very low protein content the best pastry; but these generalizations are subject to exceptions.

In the past, large quantities of California wheat that did not meet the standards of the food industries were used for livestock feed, chiefly poultry. Wheat as a grain for livestock other than poultry is nearly equal in feeding value to corn. Since wheat is a very "heavy" feed and rather pasty, you will obtain best results with large animals, especially beef and dairy cattle, if wheat makes up no more than one-third of the concentrate mixture. Wheat is an acceptable feed for swine and produces the best over-all results when mixed in a ration of corn or barley.

When various grains are fed to poultry, the birds usually show a preference for wheat. In a poultry ration, the energy value of wheat is just slightly less than that of corn.

In recent years, based on cost and energy value, other feed grains such as corn, barley, and especially milo have been better buys than wheat in California. Accordingly, less wheat than formerly has been used for poultry and livestock feed.

Occasionally California wheat—principally Pacific Bluestem—is cut for hay. For best quality, it should be cut in the soft-dough stage while the leaves are still green. Although wheat will make hay of reasonably good feeding quality, livestock seem to prefer oat or barley hay.

Varieties

The principal varieties grown in California are white wheats with spring-growth habit. Occasional fields of hard red winter wheat are grown in the northern mountain valleys, but statewide they are of limited importance. This is because they do not generally yield as

IDENTIFYING WHEAT VARIETIES

Once headed, wheat varieties can be identified by a combination of spike and kernel characteristics as set forth in the key below:

Awn .... Beard or bristle extending from the tip of the lemma

Awnletted ..... Very short beards, usually only on florets at apex of spike

Beak .... Point of projection at the tip end of the glume

Floret .... Includes lemma, pollen, and enclosed flower

Glabrous ...... Smooth, no hairs

Glume .... "Scales" or bracts at base of spikelet

Keel .... Ridge resembling the keel of a boat on the glume of durum wheat

Lemma .... Bract above the glumes which, together with the other bract (palea) surrounds the grass flower

Palea .... Inner bract of a floret in grasses lying next to the kernel

Pubescent ..... Covered with fine, soft, short hairs

Spike .... Entire inflorescence on one stem (seed head)

Spikelet .... Basic unit of the inflorescence consisting of two glumes and one or more florets

KEY TO WHEAT VARIETIES

A. Glumes not strongly keeled
- B. Spike dense (compact)
  - C. Palea nearly as long as lemma .... Big Club 43
  - CC. Palea noticeably shorter than lemma .... Poso 48
- BB. Spike lax to mid-dense
  - C. Spike awned
    - D. Spike uniformly lax; kernels long, semi-hard ...... Baart 46
    - DD. Spike moderately compact toward tip; kernels short, soft Onas 53
  - CC. Spike awnless to awnletted
    - D. Glumes pubescent .... Galgalos
    - DD. Glumes glabrous
      - E. Glumes bronze .... Ramona 50
      - EE. Glumes white
        - F. Spikes awnless (or an occasional short tip awn)
          - G. Spike moderately compact toward tip; kernels soft .... Onas 41
          - GG. Spike of uniform density; kernels hard .... White Federation 54
        - FF. Spike awnletted .... Pacific Bluestem 37

AA. Glumes sharply keeled, spikes laterally compressed ..... Sentry (durum)

The Principal Califo

Variety*	Origin	Description†
Ramona 50	[(Martin × Hard Fed.^{3}) × Ramona^{6}]^{2} × Ramona 44. Released 1950.	Very early; short; awnless; bronze glumes; stiff straw Large seeds, generally hard.
White Fed. 54	Eureka × White Fed. 38^{7}. First backcrosses made in Australia. Released 1955.	Moderately early; short; awnless or slightly tip awned; white glumes; stiff straw. Seeds short, medium size open crease, generally hard.
Baart 46	Baart 38 × Baart^{2}. Released 1947.	Medium maturity; tall; weak straw; awned. Seeds larg and long, pear shaped, small germ and creased, generall hard.
Onas 53	(Kenya × Onas 41^{5}) × Awned Onas 49^{2}. Released 1953.	Medium maturity and height; stiff straw; awned. Seed medium size, open crease, soft.
Big Club 43	[(Hope × Baart^{4}) × Big Club^{2}] × Big Club 37^{2} × (Dawson × Big Club^{6})^{2}. Released 1944.	Late maturing; tall; tip awned; club spike. Seeds mediur size, humped, small germ and crease, soft.
Poso 48	[(Martin × White Fed.^{3}) × Poso^{6}] × Poso 44 × (Dawson × Poso^{6}). Released 1950.	Early; short; tip awned; club spike. Seeds very sma and short, soft.
Pacific Bluestem 37	Martin × Pacific Bluestem^{7}. Released 1937.	Late; tall; strongly tip awned. Seeds large and fairl long, semi-hard.
Galgalos	Introduced by USDA in 1903 from Russia. First planted in Oregon.	Medium to late maturity; medium height; strongly ti awned; glumes pubescent and light brown. Seeds white medium long, soft, slightly humped, small germ an narrow crease.
Sentry Drum	Langdon 308 × Nugget sel. Developed and released coop. by North Dakota Agricultural Experiment Station and USDA.	Medium maturity; tall; awned; glumes bronze; mediur straw strength. Seeds large and long, germ midsize crease narrow, hard and translucent.

* All varieties are white spring types unless otherwise shown.
† All varieties, except Galgalos and Sentry Drum, are products of University of California and USDA plant breeders, Davis.

much as well adapted California spring varieties. Nor is the quality of wheat usually produced from these varieties under our climatic and cultural conditions as good as required by the mills.

The true winter wheat varieties require low temperatures to initiate flowering. To insure flowering and seed production, such varieties must be planted early in the fall. Spring varieties do not have the low temperature requirements. Since the majority of California's wheat acreage is planted in the fall, our spring varieties are sometimes erroneously called winter wheats.

In recent years about 8,000 acres annually of durum wheat has been produced successfully in the Tulelake Basin of northern California. When grown in most other areas of the state its quality has not been acceptable to the industry.

In a 1959 statewide survey the California Crop and Livestock Reporting Service found a rather marked shift in

Pest reactions‡	Market use	Adaptation
Resistant to bunt. Moderate stem rust resistance. Susceptible to septoria.	Milling. Bread and family flour when protein level is 12 per cent or above. Breakfast cereal.	Principally southern 2/3 of California. Late winter planting in Sacramento Valley. Seldom shatters. Frost injury at heading or severe Septoria likely from early sowing. Tillers poorly so more seed must be sown. Poor competitor with weeds. Performs well under low-rainfall conditions.
Resistant to bunt. Highly resistant to stem rust; combines two types of stem rust resistance (Hope and Eureka).	A feed wheat. Rarely milled.	General, under irrigation or good rainfall. Grown extensively dryfarmed in San Luis Obispo County. May shatter in windy areas.
Resistant to bunt. Moderate stem rust resistance.	Milling. When protein is low used for cake, pastry, cracker, biscuit and pretzel flour. Breakfast cereal.	General, performs well in low-rainfall areas. May shatter in windy areas. Avoid sowing late because of yellow-dwarf susceptibility. Lodging likely under fertile conditions.
Resistant to bunt. Resistant to stem rust.	Milling. Principal use for pastry or cake flour, especially when protein content is low.	General, not recommended in low-moisture areas. Late hot winds may wither or shatter. Currently used principally at elevations over 700 feet where later-maturing varieties are necessary because of frost hazard.
Resistant to bunt. Moderate stem rust resistance; Hessian fly resistant.	Milled for cake and pastry when protein is low and test weights are high.	Heavy soil types with moisture to support its late maturity. Shatter resistant. Latest maturing variety, which increases chance of heat or drought damage in hazardous areas.
Resistant to bunt. Moderate stem rust resistance; some of the plants are resistant to Hessian fly.	Principally used for feed. May be used for pastry flour.	Does well on heavy and poorly drained adobe soils, if not too weedy. May shatter. Small seed does not mean poor yield.
Resistant to bunt. Susceptible to stem rust.	Milling. Bread flour. Best wheat for hay.	Sierra foothills and north mountain counties, including red soils. Has considerable winterhardiness. Rust and lodging likely if crop is heavy.
Susceptible to bunt and stem rust.	Milled occasionally; bread flour. Used principally for feed.	Northern mountain counties only.
Resistant to stem rust.	Milled for semolina.	Tulelake area.

‡ Resistance to a disease implies resistance to those races or strains of the disease prevalent in California in 1960.

leading wheat varieties. The results are compared below with data compiled in 1949 by Loren L. Davis, University of California Extension Agronomist.

Varietal type	Per cent of total acreage 1949	1959
Ramona	25	42
White Federation	32	28
Onas	5	12
Baart	20	5
Others	18	13
Total	100	100

Acreage of Ramona 50 and Onas 41 and 53 has increased because the trade found their milling and baking characteristics desirable; they are being readily purchased for milling. Ramona's popularity is also increasing because of its early maturity and high yielding characteristics. Big Club 43 was planted in 2.6 per cent of the total acreage (included under "others"), and is also a desirable milling wheat for cake and pastry flour. Acreage of Baart 46 is decreasing be-

Wheat Variety Performance 1948–1959 (Incl.)

UNIVERSITY OF CALIFORNIA, DAVIS

Variety	Ave. yield, bu./a.	Date headed, 1956*	Ave. mature height, in.	Ave. shatter,† per cent	Lodging 1956,‡ per cent	Ave. bushel weight, lbs.
Baart 46	44.1	4/20	50	3.5	85	61.0
Big Club 43	31.4	5/3	47	0.0	60	58.3
Onas 53	41.6	4/24	45	6.0	45	58.0
Poso 48	40.2	4/18	44	1.0	20	60.9
Ramona 50	44.8	4/5	40	1.5	0	59.4
White Federation 54	44.4	4/14	44	8.7	40	59.7

* Heading data for 1956 is typical of that obtained in most years from early November seeding at Davis. Date of heading provides a guide as to normal range of maturity of varieties. Drought conditions after heading may narrow differences.

† Average of 4 years (1955, 1956, 1957, and 1959). In other years shatter losses in all varieties were so low as not to be significant.

‡ Lodging data is only for 1956. In other years lodging was not a problem in any of the varieties.

cause commercial interest in it for milling is currently low. The other varieties, principally used as poultry feed, have declined as interest in milling wheats has increased, and the competition of other feed grain has intensified.

The table on pages 6 and 7 describes the principal wheat varieties in commercial use in California. All varieties in the table, except Galgalos and Sentry durum are products of the University of California and USDA plant breeders, Davis. Red wheats and antiquated early-day California varieties (i.e. Sonora, Bunyip, and Escondido) are economically unimportant and are not included in the detailed variety description.

A continuing variety testing and evaluation program is being conducted at Davis cooperatively by the University of California and the USDA. The table on this page presents variety data collected and summarized annually by C. A. Suneson. Unless otherwise noted, data represent an average of eight or more years.

Variety Test Results

Desirable wheat varieties need to have not only genetically inherent high yielding ability, but other specific characters such as disease and shatter resistance. A shatter resistant variety such as Big Club 43 or Ramona 50 should be grown in a windy area if it is to be harvested for grain. A rust resistant variety such as White Federation 54 or Onas 53 should be grown in a district having a consistent history of stem rust.

Date of sowing also should be considered in choosing the variety to grow. Early maturing varieties such as Ramona 50, in general, do best in the dry, hot areas of California and may be used also for late sowing; late maturing varieties such as Big Club 43 are best adapted to cooler areas, where winter growth is restricted by wet soils.

A long-time variety testing program at Davis and throughout the state, in cooperation with the University's county farm advisors, provides current information upon which a choice of varieties may be based.

The table on page 9 shows the relative grain yield in tests of the seven leading California wheat varieties in the key areas of California. In selecting your wheat variety, consider end use as well as yield. Since the purpose of the county cereal variety testing program is to determine the relative performance of varieties, yield in the table is expressed in per cent of that of improved lines of White Federation grown simultaneously in the nurseries. Depending upon the seeding rate, date of planting, fertility

Grain Yield Comparison of Wheat Varieties

(expressed in percentage of White Federation yields)

Average of all Farm Advisor Tests,* 1947–57 inclusive

Varieties	Zone I		Zone II		Zone III		Zone IV		Zone V		Zone VI		Zone VII	
	No. tests	Per cent of WF	No. tests	Per cent of WF	No. tests	Per cent of WF	No. tests	Per cent of WF	No. tests	Per cent of WF	No. tests	Per cent of WF	No. tests	Per cent of WF
Baart 46	46	82.1	78	88.3	67	81.2	53	97.4	10	89.2	20	95.8	1	80.2
Big Club 43	11	67.3	44	88.9	43	83.1	52	97.4	10	122.0	10	96.1	2	93.3
Onas 41 (awnless)	18	96.1	52	104.5	36	104.2	21	102.9	3	111.6	13	121.9	..	.....
Onas 53 (awned)	11	99.5	23	119.8	11	107.9	13	102.8	3	78.1	8	100.3	1	101.1
Pacific Bluestem 37	1	83.0	14	100.4	25	76.6	19	85.6	5	133.0	14	82.6	2	90.8
Poso 48	27	93.9	61	100.0	59	94.3	46	102.5	10	120.6	16	93.8	2	93.3
Ramona 44 & 50	64	102.0	96	102.2	63	97.4	48	94.8	7	104.9	19	97.6	1	92.0
Mindum Durum	..	.....	1	60.4	..	.....	..	.....	..	.....	2	76.3	..	.....
Sentry Durum	..	.....	6	81.1	2	87.5	2	65.1	..	.....	3	69.3	..	.....
Counties in zones	Imperial Los Angeles Riverside San Bernardino San Diego		Alameda Contra Costa Monterey Orange San Benito San Luis Obispo Santa Barbara Santa Clara Ventura		Fresno Kern Kings Madera Merced San Joaquin Stanislaus Tulare		Butte Colusa Glenn Placer Sacramento Solano Sutter Tehama Yolo Yuba		Lake Napa Mendocino		Lassen Modoc Shasta		Inyo Tuolumne	

* Cooperative field investigations between local farm advisors and research workers of the Department of Agronomy and USDA.

and moisture available, yields of any one variety in any one district may fluctuate widely. For example, Ramona wheat under irrigation in the San Joaquin Valley has yielded up to 5,000 pounds per acre; under dry-farmed conditions the same variety in the same area yielded only about 1,200 pounds per acre. In 1958, commercially grown wheat yielded an average of 1,290 pounds (21.5 bushels) per acre in California.

Choosing the Seed

Use certified seed. The cost of seed constitutes a minor part of the growing of the crop. Buy seed of the best quality you can obtain. By purchasing certified seed of the appropriate variety you will be buying top quality seed, meeting high standards of purity, germination and freedom from weed seeds. Moreover, you can be certain it will have the inherent qualities which you seek in using a specific variety.

Common seed frequently can be the most expensive, even if the initial purchase price is low. In a recent experiment samples of common cereal seed voluntarily supplied from farmers' drill boxes were found to contain as high as 2,000 weed seeds per pound of seed. In many instances the samples contained noxious weeds such as morning-glory, star thistle, and whitetop. Where such seed is used, you are literally seeding your fields to these noxious weeds. This could cost you thousands of dollars in future years for weed-control measures. If you have to reseed a field because of low-germinating seed, your seed costs may be doubled or trebled just in extra seed costs.

Treating wheat seed with an effective chemical fungicide such as Ceresan M, liquid Ceresan or Panogen is recommended for the control of seedborne diseases such as bunt. In some districts soil inhabiting wireworms have seriously damaged germinating wheat. You may combine lindane or other recommended insecticides with the fungicide for added protection against wireworms. Carefully follow the manufacturer's recommendations. Too much chemical can seriously impair germination. DO NOT use treated seed for feed or food. It is poisonous, and should be so labeled.

METHODS OF WHEAT GROWING

Three methods of wheat production are common in California.

First, a fallow-crop rotation, or a variation of fallow-crop-pasture three-year rotation.

Second, continuous cropping with or without supplemental irrigation, rotated annually with one or more spring- or summer-irrigated crops such as grain sorghum, safflower, or beans. Wheat may be grown every winter, although this is not commonly done.

Third, spring seeding in areas where irrigation is frequently practiced, such as the north-eastern part of the state. Again, a crop of wheat may be grown every year; this is not universal practice.

Fallow-Crop Rotation

The alternate crop and fallow system is common in areas of less than 14 to 16 inches of average annual rainfall, where the moisture available in any one year is insufficient to produce a crop. In most wheat areas an annual rainfall of 14 to 16 inches is considered necessary for annual cropping. The fallow-crop rotation conserves moisture, and has several other benefits, among them weed control. Even in areas where moisture is sufficient for annual cropping, fallowing every third or fourth year has been essential to control wild oats. If proper moisture is available throughout the fallow year, microbial activity is encouraged, result-

ing in considerable release of essential plant foods, especially nitrogen.

The fallow-crop rotation system has two variations in some areas: a fallow crop-pasture and a fallow-crop-hay rotation. This allows for a fallow year once in three years just before the wheat crop, so that the land is as free as possible of wild oat and weed seeds during the major crop year of the rotation.

A fallow system also provides the opportunity to improve the physical condition of the soil through the incorporation of crop residue and green manure. Until some satisfactory method is worked out permitting the incorporation of crop residue in an annual dry-farmed wheat program without depressing yields, the use of green manure crops offers one of the best ways of maintaining soil organic matter.

Grain stubble should be thoroughly incorporated into the soil after the first fall rains to help insure its rapid decomposition. Where wind or water erosion are problems, a trashy coverage, somewhat like that above, is advisable. (Macdoel, California)

Continuous Cropping Fall-Sown Wheat

This method of wheat production is normally in rotation with other winter- or spring-sown crops, such as safflower or rice or a double-crop rotation with short-season (90 days) summer crops, such as beans or grain sorghum. In the latter case, pre-irrigation, land preparation and seeding take place in the fall, harvest in early summer, then land is prepared immediately for the summer rotation crop. The wheat may receive one or two crop irrigations depending on the amount of rain. Timing of operations, correct use of fertilizers and irrigation, and crop residue management are important for success in this method of wheat raising. In the Sacramento valley, rainfall is usually sufficient to produce a satisfactory crop without supplemental irrigation.

Continuous Cropping Spring-Sown Wheat

Over much of California wheat is fall sown. However, in northern California at elevations above 2,000 feet, or elsewhere where winter temperatures are severe enough to winter kill fall-sown spring-type varieties, spring seeding is common. The rotation practices vary by areas; however, irrigation is common in the Tulelake Basin. In most other spring-sown areas dry-farming is the usual practice, utilizing the crop-fallow system.

Three rotations are common with spring seeding: wheat following wheat; wheat rotated with potatoes; or a longer rotation of alfalfa or clover, barley, potatoes, wheat and then back to alfalfa. Though there are variations in equipment used and time of the initial tillage operation, the usual procedure is a rough working in the fall with a chisel or plow. The spring operations include disking; harrowing to firm the seedbed; fertilizing if wheat follows wheat; and then seeding with a drill. Following barley with wheat is not recommended because barley may volunteer in the ensuing wheat, resulting in a mixture with reduced sales value.

MANAGEMENT SCHEDULE

A management schedule or operations calendar could be outlined in considerable detail for a given system in a specific area of the state. However, because of the many variations of practices and conditions in California, only a generalized schedule of operations for the three methods of wheat growing can be given. For local details of practices and specific recommendations, consult your Farm Advisor.

Preplanting Operations

No one method of seedbed preparation is applicable in all cases. Economically, and for sound soil management, it is very important that every tillage operation serves a definite, beneficial purpose.

Important accomplishments of tillage are: incorporation crop residues, killing weeds and other unwanted plants, and preparing a seedbed. Moisture conservation results from destroying unwanted plant growth and preparing a rough surface mulch to capture rainfall. Incorporating plant residue and rough tillage can help rain and irrigation water to percolate into the soil. Excessive tillage will result in soil compaction and a surface mulch so fine that it will increase the erosion danger and impede water penetration.

To conserve maximum moisture, in a fallow system, the first heavy tillage operation should be as early as possible, usually in the fall or early winter after the first rainfall. Early tillage will also promote maximum decomposition of the incorporated crop residue. In addition, this early tillage should be rough and trashy in appearance to allow faster acceptance of winter rains and thus reduce runoff. This fall incorporation or mixing of the past season's crop residue will usually result in less nitrogen tie-up when the crop is seeded.

Where annual cropping is used, the first heavy tillage operation also usually follows the first rain, often at the time when volunteer seeds, including weeds, start to grow. Subsequent seedbed preparations usually follow closely to conserve surface soil moisture.

Deep tillage should be practiced with caution. Use it only when there is enough time and rainfall to permit the soil to settle before planting. Deep tillage just before seeding is not advisable, as it leaves the seedbed too loose and may result in excessive moisture loss and increase danger of erosion. Normally, deep tillage should be done when the soil is dry.

A variety of tillage equipment is essential because California wheat-growing conditions differ widely as to soil types, topography, and rainfall. Tilling soil at the same depth year after year will produce a "plow" pan. Variation in depth of tillage is a good practice and reduces the danger of plow-pan formation.

A good assortment of tillage equipment for differential use on plains or gently rolling land is: wheatland plow, chisel, light disk, CC cultivator or springtooth, rod weeder and spiketooth harrow. For farming hilly land a heavy offset disk would replace the wheatland plow. Heavy adobe or clay valley soils require the use of heavy disk or moldboard plows, and irrigated farms need floating or landplaning equipment and ditch and border equipment specially adapted to this type of operation.

Time and Rate of Seeding

For highest yields and economy of production the best time to sow wheat in California is November and December, except in the northern mountain counties at elevations over 2,000 feet. Here, when spring varieties are used, seeding in late March to early May will usually avoid frost injury to the crop.

Seeded at the right time, wheat will usually escape serious injury from yellow

Preparing fallow. Some growers first graze off the stubble and then plow or disk the stubble under following the first good fall rain. (Near Montague, California)

dwarf virus disease, and from frost the following spring. If seeded too early or too late, yellow dwarf problems can be intensified. Very early seeding increases the heading-time frost hazard manyfold, especially with early varieties such as Ramona.

Other important advantages of November or December seeding (where recommended):

The crop makes maximum use of winter rainfall.

It matures during relatively cool weather.

The wheat matures ahead of damaging warm-weather diseases.

Planting tests clearly point to the advantages of optimum-time seeding. In tests at the University of California Imperial Valley Field Station, El Centro, during the period 1951 to 1954 inclusive, Ramona 50 yielded 44.5 per cent and White Federation 38, 56.9 per cent when planted in February as compared to the yield of the same varieties sown in November of the preceding fall.

At Davis, Agronomy Department researchers had previously demonstrated sharp decreases in yield as the planting time was delayed (see the table below).

Wheat seeding rates in California vary from 20 to 110 pounds per acre, depending on seeding date, soil moisture and fertility levels, climatic outlook, and seeding method. In the low-rainfall, dry-farmed area of San Luis Obsipo County the average seeding rate is about 30 pounds per acre. In higher-rainfall, dry-

Effect of Seeding Date on Average Wheat Yield*

Crop year	Number of varieties	Yield in lbs./acre from various dates of seeding		
		Nov. or Dec.	Jan.	March
1928	5	1764	1626	396
1929	5	1734	1482	738
1930	5	2304	2142	348
1938	2	2574	....	240
1939	3	3150	....	2358
1941	15	2046	1458	....
1942	12	3252	....	1062†

* At U. C., Davis.
† Seeded February 16, 1942.

Fallow-Crop Rotation Soil Management Schedule

1. October through April

   First heavy tillage, offset disk, chisel or wheatland plow.

   In many districts of adequate rainfall, the heavy tillage operation may be delayed until the volunteer green feed has been grazed down in the spring. Such a practice does not conserve as much moisture as starting the fallow operation earlier.

2. Late winter

   Second heavy tillage, if needed, offset disk or wheatland plow.

   Some conditions may require use of a moldboard plow.

3. April through May

   Light tillage, springtooth, CC cultivator or tandem disk.

   Two operations will usually be sufficient.

4. Summer

   Weeding operations may be needed: a rodweeder, springtooth, or chemical sprays.

   In some areas of the state sudan grass is planted at low seeding rates on fallow land for summer pasture. Cattle will then keep many summer weeds under control.

5. Fall to early winter

   After the first good rains a preseeding tillage with a disk or CC cultivator is followed by fertilizer applications and the seeding operation. Where fall rains are long delayed, seeding may be done before first rain.

Annual Cropping Soil Management Schedule

1. October–November

   Reduce past crop residue; bale, pasture, chop, or burn (only if necessary).

   Plow or disk.

   Harrow.

   Fertilize, if needed.

   Set up irrigation system, where needed.

   Irrigate, springtooth and seed.

2. Spring or Early Summer

   Irrigate as needed.

Operations are somewhat different for spring-planted cold winter areas of the state. A good schedule for this method of wheat farming would be as follows:

1. October–November

   Reduce or chop previous crop residue. Plow, disk or chisel.

   Let land lay as rough as possible all winter.

2. Early Spring

   Disk to work down the ground and kill all weed growth.

   Fertilize if necessary.

   Set up checks and irrigate, where needed.

   Harrow to produce a firm seedbed.

   Seed with drill and cultipack.

3. Early Summer

   Irrigate as needed.

farmed districts and under irrigation the average is about 70 to 90 pounds.

There can be a fairly wide range in seeding rate for fall-sown wheat, without affecting yield, since optimum-time sown wheat plants tiller or stool freely if the stand is on the thin side. If sowing is done by broadcasting or if planting has to be delayed into late January or February, increase the above suggested rates by 15 to 20 per cent. Spring-sown wheat does not tiller as freely as that sown in the fall. Broadcast seeding followed by disking or harrowing results in a total of about 20 per cent of the seed either being too deep or too shallow for effective use.

Seeding

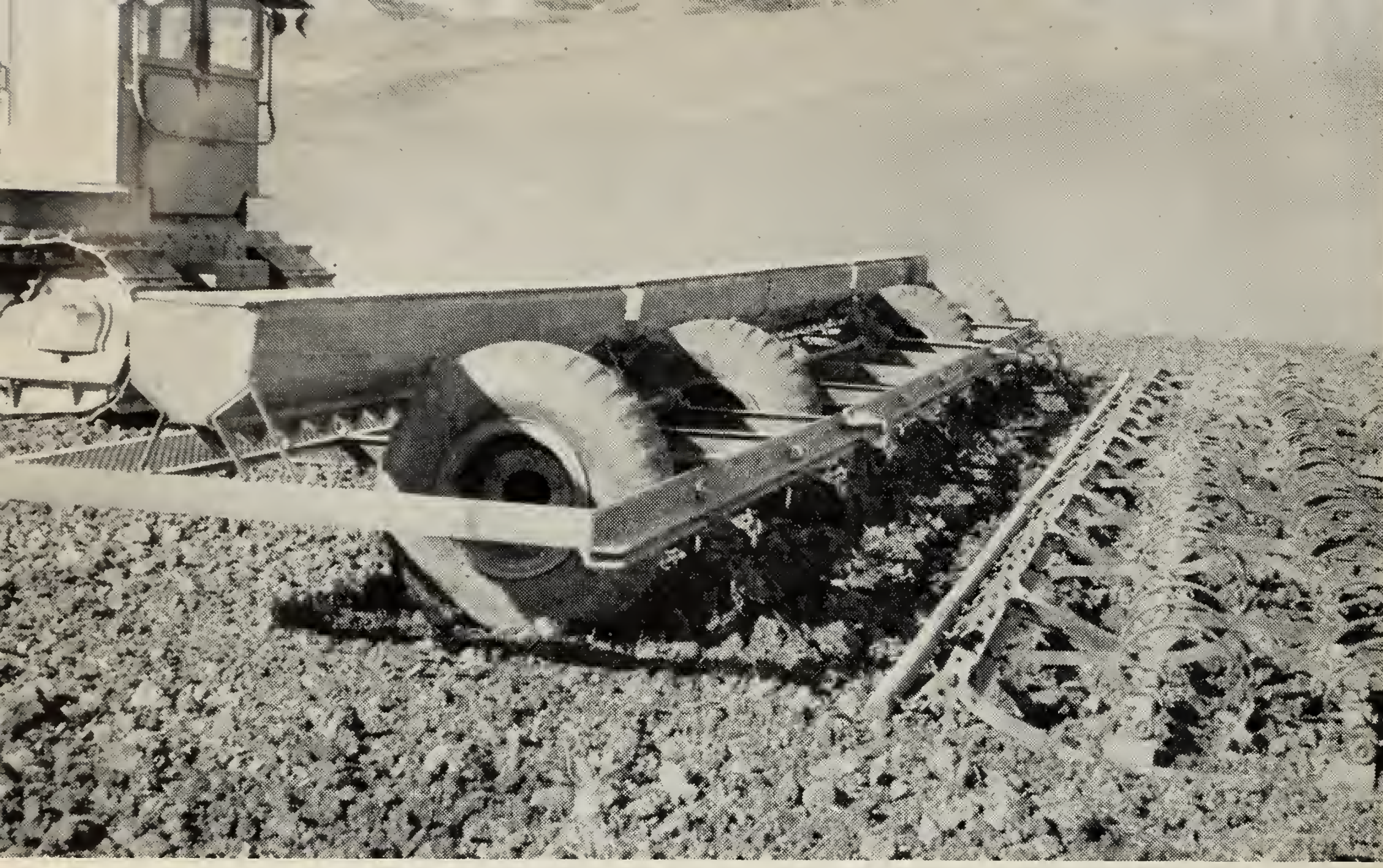
In fallow-crop rotation, proper maintenance of the fallow during the summer will normally provide an excellent seedbed for the following crop. However, it may be advisable to delay fall planting until after the first rains to provide an additional chance to control weeds. Planting before continuous rain is assured may result in partial germination and loss of the seedling stand by drought. The top zone of fallowed land will rarely retain enough moisture to germinate the seed and sustain plant growth before the first rains.

The actual seeding method and equipment used will vary from one area to another. The two principal methods are broadcasting and drilling.

Broadcasting is the seeding method used on probably three-fourths of the wheat in California. One method frequently used includes a preseeding tillage operation to kill weeds and prepare a seedbed. The seed is then broadcast with a regular drill box (without openers) mounted on a heavy cart which pulls a light disk or springtooth type of cultivator, to cover the seed and kill any remaining weeds. These seeding units range from 20 to 50 feet in width; acreage covered varies from 5 to 15 acres an hour. This operation is usually followed by a spiketooth harrow to smooth out and firm the seedbed.

End-gate type seeders and airplanes are used in many areas after the seedbed is prepared. After broadcasting, the seed is then covered with a spiketooth harrow. On some wheat farms seedbed preparation, weeding, seeding and harrowing are carried out in one operation by mount-

Some wheat growers combine final seedbed operations, fertilizing and seeding into a single-time-over operation. This usually works best on land which has been fallowed. (Near Roseville, California)



This is a CC cultivator-seeder, popular in San Luis Obispo County wheat districts. The seeder broadcasts or drops the seed onto a prepared seedbed. The following spring-tooth harrows cover the seed.

ing a seed box on a flexible disk tiller with harrows pulled behind the same unit. These tillers are similar to wheatland plows (only lighter) and generally till the soil as deep as a plow.

Drilling instead of broadcasting often results in a more uniform, weed-free stand, less lodging, and usually higher yields. In some spring-sown areas, a firm seedbed is very important to conserve moisture; hence press drills are in common use, or a disk drill is followed by a ring roller. This practice is used frequently where spring-sown wheat land is irrigated before seeding.

Wheat is usually drilled or covered to a depth of 1½ to 2 inches. Planting deeper than 1 to 2 inches is advantageous only in placing the seed into moisture to insure uniform germination. Planting deeper than 2 inches can result in poor stands, especially on clay-textured, cold soils.

Experience will show you what method will give you a clean even stand of wheat consistently at the lowest cost under your conditions; use that method.

Fertilization

The kind and amounts of fertilizer you can use profitably in your wheat fields, depend on soil type, soil-moisture situation, length of growing season, native fertility level, and the cropping history of your field. Your farm advisor can usually suggest the most effective practices, based on local tests and observations.

Nitrogen. On most soil types in the dry-farmed grain areas, the application of about 20 to 40 pounds of nitrogen (100 to 200 pounds of ammonium sulfate or its nitrogen equivalent) has resulted in profitable increases in wheat grain and forage under usual moisture conditions. Crops following fallow may show little or no response to nitrogen, unless the annual rainfall exceeds 10 to 12 inches.

Under irrigated conditions, grain or forage yields usually can be increased with more liberal amounts of nitrogen, ranging from 20 to 80 pounds of actual nitrogen per acre. If considerable straw or non-legume crop residue is incorpo-

rated in the soil shortly before seeding the wheat, it may be desirable to use an additional 20 to 30 pounds of nitrogen to offset the temporary nitrogen deficiency during the crop residue decomposition. Little or no supplemental nitrogen may be needed where the wheat follows alfalfa, irrigated pasture, heavily fertilized row crops or legume green manures.

On sandy soils, or those subject to marked leaching, apply one half of the nitrogen fertilizer (as ammonical N) at seeding time and the remainder as a top dressing (as nitrate N) when the crop is 4 to 6 inches tall, a stage of rapid growth and large demands for nitrogen. Nitrogen applied after the jointing stage has less effect on yield but may influence crop quality.

Nitrogen stimulates plant growth and excessive applications often cause overstimulation, ultimately resulting in severe lodging, delayed maturity, increased susceptibility to diseases and exhaustion of soil moisture.

Phosphorus. Fertilizers containing phosphorus in combination with nitrogen have given economical responses on some poorly drained old terrace or plains soils with strong claypan or hardpan development. Such soils include the Corning, Kimball, Hartley, Huerhuero, San Joaquin, Rocklin, Aiken, Linne and Altamount. Some older alluvial soils in the floor of the Central Valley (Delano, Ducor and Ramona) are borderline deficient and may respond to phosphorus as well as nitrogen application under continuous heavy cropping.

Phosphorus fertilizer preferably should be drilled, but may be broadcast and then disked or harrowed in so that it is placed several inches below the surface. It may be applied in combination with nitrogen, where both are needed, providing the fertilizer is drilled in or broadcast followed by disking or harrowing.

Phosphorus needs can be determined by test strips across a field and in many instances by soil analyses. The sodium bicarbonate ($NaHCO_3$) method of testing soil for available phosphorus has usually proved satisfactory. Cereal crops ordinarily respond to added phosphorus when the $NaHCO_3$ extractable phosphorus is less than 30 pounds P_2O_5 per acre. If phosphorus is needed, the equivalent of about 20 to 60 pounds of water soluble P_2O_5 per acre, either as a combination nitrogen-phosphorus fertilizer or as single super-phosphate or treble super-phosphate, may be applied.

Some growers mix the seed and fertilizer and drill them together. This practice is not recommended. It definitely is risky where the rate of fertilizer application exceeds 150 pounds of total material per acre, and it may injure the seed or seedlings at rates as low as 100 pounds per acre. Experiments in California and elsewhere with foliar spray applications of urea or other nitrogen solutions to cereal crops have not been particularly promising.

University field trials have shown some responses to sulfur and possibly to zinc, but little response to potassium and none to elements other than those mentioned.

Weed Control

The troublesome weeds in wheat fields include: grassy weeds such as wild oats, darnel, and ripgut; and broad-leaved weeds such as wild radish, mustard, star thistle, fiddle-neck and wild sunflower. The first group can be controlled by well-timed seedbed preparation; the second by chemicals.

Wild oat infestations are difficult to control, for the seeds shatter readily and are subsequently plowed under or trampled into the soil. They may lie dormant for several years in the soil but will germinate and grow when they are returned to the surface by later cultivation. Wild oats were introduced into California during the Mission period, as a contaminant in barley, wheat, and oat seed.

Control of grassy weeds. Wild oats and other troublesome annual grassy weeds can be controlled by delaying final seedbed preparation operations until rains have germinated the seeds that are at or near the soil surface. Disking or harrowing will then kill most of weedy grass seedlings, and the seeded crop becomes established before the weeds again are abundant. This practice also is useful in controlling broadleaved weeds. In some coastal areas of California the grain fields are so weedy that several well-spaced diskings during the winter are necessary, with seeding being delayed until early spring.

Certain new chemicals for selective wild-oat control in wheat have appeared promising in early tests. For current information on these and other weed control recommendations consult your local Farm Advisor.

Control of broad-leaved weeds. Most of the commonly occurring broadleaved weeds can be controlled by spraying weedy grain fields with selective chemicals such as amine 2,4-D or MCP. Use ½ to ¾ pound of active chemical per acre, applied in 3 to 15 gallons of water by airplane or 15 to 50 gallons by ground rig. Wheat plants should be 4 to 6 inches tall and tillering, when treated. The crop normally should not be sprayed after jointing has begun.

Some farmers prefer to use MCP, which can be less injurious to wheat than 2,4-D. Where very resistant weeds such as fiddle-neck predominate in the field, the low volatile ester formulations of 2,4-D or MCP at the rate of ¼ to ½ pound of active chemical per acre may prove more effective than the amine formulations, but they may cause more injury to the wheat than the amine formulations.

In some areas, especially in those in which the use of hormone-type herbicides is restricted by law, the dinitro compounds are used to control seedling broad-leaved weeds when the crop is from 4 to 6 inches tall. Follow the manufacturers' recommendations as to amount and method of applying dinitro herbicides.

Growers using 2,4-D or MCP or other hormone-type herbicides, under provisions of the law, must first obtain a permit from their local Agricultural Commissioner.

Grazing Wheat

When wheat is young it can, under certain circumstances, be grazed or clipped to reduce the likelihood of later lodging (if growth appears excessively rank). Either practice may be used in an attempt to prevent frost damage resulting from too early heading. If the field is mowed, promptly remove the mowed green material from the field to avoid damage to the stand.

If there is enough fertility and moisture to safely mature a crop, grain yields are not seriously reduced by grazing or clipping before the onset of jointing or stem elongation (while it is from 4 to 6 inches high). Grazing will decrease yield if jointing is very far along, or if the field is grazed when the soil is wet, or if moisture or fertility is inadequate. Young wheat plants are rich in protein and minerals and most stockmen consider them excellent pasturage.

Irrigation

Only in low-rainfall areas of the state, where supplemental water is available, is wheat irrigated. Such areas include the Imperial and San Joaquin valleys, the Tulelake Basin, and, in low rainfall years, some areas of the Sacramento Valley. In general, if 14 to 16 acre-inches of water is available per crop year either from annual rainfall or through a combination of fallow-crop rainfall, wheat irrigation is not practiced.

In deep permeable soils, wheat roots will grow to a depth of 4 to 6 feet. In general, wheat will root somewhat deeper than barley. Consequently, irrigation

practices should be so managed to provide moisture to that depth.

In areas which rely almost entirely on irrigation, three irrigations totaling about 15 to 20 acre-inches per acre are normally enough. Apply the first irrigation before planting and wet the soil to the full depth. Irrigating a crop immediately after planting (before germination) may leave the soil in a compacted, crusted condition which can interfere with the normal emergence and development of the plants and is not recommended.

With fall-sown grain, cool weather usually prevails during the early growth stages so that the preplanting irrigation should be sufficient to sustain the plants until the jointing or stem-elongation state. At that time apply the second irrigation unless there had been sufficient rain. The third irrigation, if needed, can be given about the time of flowering.

When only two irrigations are used, delay the second until late jointing or even to the boot stage. Moisture stress between the jointing and heading stages is more injurious to the plants than in the earlier or later stages of development. Irrigation after the milk stage is seldom beneficial or economical. Where water penetration is a problem, it may be necessary to irrigate more frequently.

Irrigation after flowering often results in excessive amount of "yellow berry" thus reducing the quality of the wheat, especially when high protein is desired. Irrigation or rain at that critical time may reduce the availability of nitrogen for the developing crop. An adequate supply of nitrogen is necessary for protein production in wheat.

In areas or seasons of high rainfall, unnecessary fall and early-spring irrigations may result in water-logging, which can be harmful to plant growth. This is especially true on relatively impermeable, claypan or hardpan soils. Wheat will withstand such conditions better than barley, but yield can be reduced.

Excessively wet soils lack adequate aeration, may be low in nitrogen because of leaching or nitrogen loss to the air, and generally favor root-rotting organisms. Any one or all of these factors may be operating where wheat is "drowned out."

Harvesting

To harvest the California wheat crop combines are used exclusively—mostly the self-propelled combine, either level or self-leveling; in occasional fields the old-model trailed machines with end-delivery headers.

For satisfactory harvest, both the straw and kernels should be dry; for safe storage the moisture content of the harvested grain should not be over 13 per cent and free of green weed trash. If grain is harvested while damp with dew, it should be blended with dry grain. It is advisable to windrow the crop rather than combine direct when the field is contaminated with many green weeds. After the weeds have dried in the windrow, harvest the crop with a combine equipped with a pick-up attached to the header. The dry weed plant and seed can usually be separated from the grain during combining.

The wheat may be discolored and acquire off-flavors if green weed trash and seed are mixed with the threshed wheat. This reduces or eliminates its value for human food may cause heating, and also makes it subject to insect damage during storage.

Follow recommendations for harvester adjustment and operation in the Operator's Manuals furnished with the combines. Settings within the recommended ranges of adjustments will vary depending on the season, variety, weather, and crop conditions. A round hole clean grain sieve (about $^{15}/_{64}$ inch) is normally used. However, the crop can usually be satisfactorily harvested with the adjustable clean grain sieve. The following are some special money-making har-

vesting tips which apply to all makes of self-propelled combines and most trailed machines.

(1) Hold reel losses to a minimum by maintaining a peripheral reel speed that is 1.25 to 1.50 times greater than the forward ground speed of the combine. With lodged grain the peripheral reel speed should be about double the forward speed. To compute the peripheral speed of the reel in miles per hour, multiply effective reel diameter in feet by 3.14 and the number of reel shaft revolutions per minute; then, divide this product by 87.3. The effective reel diameter is twice the distance from the outer edge of the reel bat to the reel shaft center. For pick-up reels, it is twice the distance from the rod or pipe carrying the pick-up fingers to the reel shaft center.

(2) If you use a finger-drum type pick-up, the tip speed of the fingers should be about 25 per cent greater than the ground speed. Use the computations outlined above to determine the finger-tip speed.

(3) Set the shaft on pick-up reels far enough in front of the cutter bar so that the straw is released by the fingers just as it is being cut. The bat reel shaft should ordinarily be 6 to 10 inches ahead of the cutter bar and at a height such that the bats contact the straw just below the heads.

(4) Set the engine governor to give the harvester reference shaft speed recommended by the manufacturer. Check this speed with a high quality tachometer or a stop watch and revolution counter.

(5) Set the cylinder speed by selecting the appropriate roller chain sprockets or by changing V-belt pulley pitch diameters. Do not adjust the cylinder speed on self-propelled combines by changing the engine governor setting. Below are listed a range of cylinder speeds and concave adjustments which will give adequate threshing without excessive mechanical damage to wheat when the weather is hot and dry during harvest:

Cylinder speed—4,500 to 5,500 feet per minute

Cylinder-concave clearance—$\frac{3}{8}$ to $\frac{5}{8}$ inches

Rows of teeth in concave—2 to 4

Harvest time—wheat is ready to harvest when the grain is down to 13 per cent moisture or less and the straw is dry. Both self propelled and tractor drawn combines are used to harvest California's 375,000 acres of wheat. (Near Shandon, San Luis Obispo County)

Note: Divide the desired cylinder speed in feet per minute by 3.14 times the cylinder diameter in feet to obtain cylinder shaft speed in revolutions per minute.

(6) Cylinder speed and the clearance between the cylinder and concave bars, or the rows of teeth in the concave and the overlap between cylinder and concave teeth, should be such that only an occasional seed remains in the head and there is little cracked seed in the grain tank.

(7) Check seed loss over the shoe with a $^{15}/_{64}$ inch round hole seed dockage pan placed on top of a blank pan. High unthreshed seed loss in the straw is a result of poor threshing or insufficient material passing through the cylinder. An increase in cylinder speed or overlap between cylinder and concave teeth or in the amount of straw fed into the cylinder will each or in combination reduce the loss of unthreshed seed. It may be necessary to add one or two rows of teeth in the concave or decrease the cylinder-concave clearance to obtain adequate threshing. Good threshed seed lost with the chaff over the shoe is usually the result of overloading the machine. This loss can also be caused by incorrect wind adjustment as well as the shoe sieves not being open enough. The adjustable chaffers should be at least one-half inch open and adjustable clean grain sieves be at least one-quarter inch open. Chaff in the grain tank usually indicates too little wind. If the chaff is being lifted off of the top shoe screen, there is too much wind. The chaffer extension should be level or slightly raised and open at least as much as the chaffer.

(8) When the crop is being harvested for seed, use cylinder speeds in the lower end of the recommended range—particularly if the wheat is very dry. If the field is in a locality of high humidity during harvest, it may be necessary to use cylinder speeds as high as 6,000 feet per minute to obtain a satisfactory threshing job for either seed or grain.

(9) A straw spreader or chopper attached to the rear of the combine scatters the straw evenly over the field as harvest progresses. By so doing postharvest tillage operations proceed more smoothly, and nitrogen tie-up due to excessive straw in windrow areas is eliminated. Leave the straw in the windrow that is to be baled or pastured after harvest.

Farm Storage

In California wheat is usually stored on the farm in bulk. The length of storage time depends on grain condition, market demand, and the desire of the farmer to move his crop. When the crop is moved to market, most of it moves in bulk directly by truck. Sacking is rare and mostly confined to the seed market.

Sacking of wheat had its start in California in the late 1800's, as the wheat crop was hauled to the coastal ports in wagons and shipped by boat to overseas markets. The holds of these ships did not have partitions or cross bulkheads to prevent the shifting of bulk grain. Sacking continued until about 1925 when bulk handling got its start. By 1941 nearly all the state's grain growers had changed to bulk handling. Today the bulk truck, bulk farm storage bins and central bulk bin have replaced sacks, sack bucks, the flat bed wagons, roadside stacks of sacked wheat, and the country point flat warehouse sack storage.

Farm storage bins may be concrete, wood or steel and are equipped and filled with power-driven belt or auger elevators, or complete hillside gravity-flow installations. Round steel bins set on good, well drained foundations and with weatherproof roofs usually keep the grain in good condition. In some cases barns, flat warehouses and rectangular steel buildings have been adapted for bulk storage of wheat. Steel bins with sealed joints, such as old oil tanks, and most commercially available steel bins with self-sealing joints have advantages of being more weatherproof, and fumi-

gation is more easily done with this type of construction. To keep farm-stored wheat in good condition, it should be dry, cool and free of insects and other types of contamination.

A good clean grain program begins well before harvest. Thoroughly clean before harvest the bins, all conveying equipment, pits, dumps and harvest equipment of all old grain. Clean up and burn all trash around the storage area. All of these, if not cleaned up, are sources of new insect infestation for your new crops. Spray inside the bins, elevators, spouts, pits and augers with an approved insecticide. Your Farm Advisor can supply you with a list of currently recommended materials and procedures. Next, spray all outside areas that the wheat does not contact, including the tank, foundations and the ground for 50 feet around the bins with DDT. Another very important sanitation precaution is to screen out or otherwise prevent rodents and birds from gaining access to the stored grain. Sanitary regulations of the U. S. Food and Drug Administration and local health officials are making it mandatory that food crops such as wheat be protected from unsanitary contamination of any kind.

After the storage facilities are in use, check them regularly every several weeks for rain leaks, nesting birds, invading rodents, and insect infestations. Prompt corrective action will help you maintain a high-quality product and save you dollars. Fumigate insect infestations with an approved chemical.

DISEASES OF THE GROWING CROP

A number of diseases contribute to the hazards of wheat production. Fortunately two serious diseases, stem rust and bunt (stinking smut), are fairly well contained by use of resistant varieties. In addition, seed treatment, good cultural practices, selection of adapted varieties and utilization of disease-free seed all help to keep losses low from other diseases.

Treat seed with an approved fungicide before planting. Organic mercurials such as Ceresan M, liquid Ceresan or Panogen are recommended. Wherever wireworm control is necessary, you may add an insecticide such as lindane or aldrin to the fungicide. Improper chemical usage may reduce germination—always follow the manufacturer's recommendations as to amounts and treating procedures. Treated seed must not be used as feed or food since the materials are highly poisonous.

Bunt or stinking smut, at one time the most serious wheat disease in California, is seed borne. Infection of the seedling follows germination, with the fungus becoming established in the growing point of the plant. Grayish-black small balls filled with millions of black minute fungal spores are formed in place of kernels. During harvest these smut balls are ruptured and the spores scattered, contaminating healthy kernels and often being carried by air to adjacent areas. Subsequent infection resulting from soil contamination, although common in parts of the Pacific Northwest, is of little importance in California. Most of the California varieties (see the table on pages 6 and 7) are resistant to the strains of bunt prevalent in California. However, strains capable of attacking the resistant varieties have been collected. Seed treatment will help keep these new strains under control.

Stem rust can be highly destructive and may result in complete loss of the crop. Before the development of resistant varieties, statewide outbreaks averaged once every four or five years. Localized out-

breaks occurred every year. Since 1941, losses have been held to a minimum by the use of resistant varieties.

The disease can be recognized by elongated pustules filled with red spore masses which break through the surface of the host stem tissue. Later in the growing season or under conditions unfavorable for disease development, black spore masses may be produced within the same pustules. Although concentrated on the stems, pustules occur on the leaves and floral parts. Under the most severe conditions the plants may be killed, but normally are weakened so that the kernels fail to fill properly, are shrivelled and low in test weight.

The spores are air borne, and fields become infected from spores blown from adjacent wheat fields, volunteer plants, and some wild grasses. High humidity and slightly higher-than-normal spring temperatures favor rust development. The only control is through the use of resistant varieties (see the table on pages 6 and 7).

Yellow dwarf is not as readily recognized in wheat as in barley and oats, although it may be of equal importance. In contrast to the red discoloration in oats and the brilliant yellow in barley, both accompanied by severe dwarfing, infected wheat plants normally show a rusty to yellowish-brown discoloration with only a moderate degree of dwarfing. Severe infection of young plants usually will result in a marked stunting of the plants. Discoloration begins at the tips of the upper leaves and progresses to the base. Infected plants may exhibit a high degree of sterility and a high percentage of shrivelled kernels even though the plant appears to develop normally.

Yellow dwarf is caused by a virus which is transmitted from plant to plant by any one of several species of grass-inhabiting aphids. Plants infected in the early growth stages are the most severely damaged. Timeliness of planting, avoiding early (prior to November 1) or late (February or after) planting dates offers the only practical means of reducing losses. Plantings between the above dates normally escape the late aphid flights in the fall and have reached considerable growth before the heavy spring flights. All of the present California varieties are equally susceptible.

Root rot may be caused by several soil-inhabiting fungi and is usually applied to all diseases that affect the roots, crown and other basal parts of the plant. Symptoms vary from a stunted, unthrifty appearance to actual death of the plant. The roots, crown and basal parts of the stem are usually discolored. Occasionally, considerable stem breakage may occur. Since destruction of these tissues interferes with the normal uptake of water and nutrients, plants may appear to be suffering from drought or other stresses. Such plants may seem bleached, and if such stresses are imposed at flowering time or later, sterility and shrivelling of the kernels may be evident.

Root rot causing fungi multiply in the soil when susceptible crops are grown continuously. Wheat and barley are equally susceptible, and the same organisms attack both. Fortunately, oats are fairly tolerant and you may obtain satisfactory control by including them in rotation about every third crop year.

Septoria leaf spot, while not widely prevalent in California, may cause considerable defoliation of the susceptible variety, Ramona 50. The other commercial varieties are sufficiently tolerant to escape any pronounced damage. Spots of irregular outline, which first appear as light green to yellow areas but later take on the characteristic light to dark brown discoloration, spread rapidly, frequently over the entire leaf blade. The most distinguishing and final means of identifying the disease is the forming of small, scattered, black fruiting bodies on the dead leaf tissue.

The disease is favored by cool, moist weather. No complete control is known,

but both crop rotation and sanitation help to keep the disease down.

Other diseases, such as leaf rust and stripe rust, may occur but are of little economic importance at the present time. Leaf rust may be difficult to distinguish from stem rust. However, leaf-rust pustules are small, round to slightly oblong, and orange-yellow, in contrast to the larger, elongated, red stem-rust pustules. The pustules of stripe rust are small and elongated in form and bright orange. They are usually confined between the parallel veins of the leaf and united end-to-end to form long, yellow stripes. No satisfactory methods of control are available for either disease.

INSECTS OF THE GROWING CROP

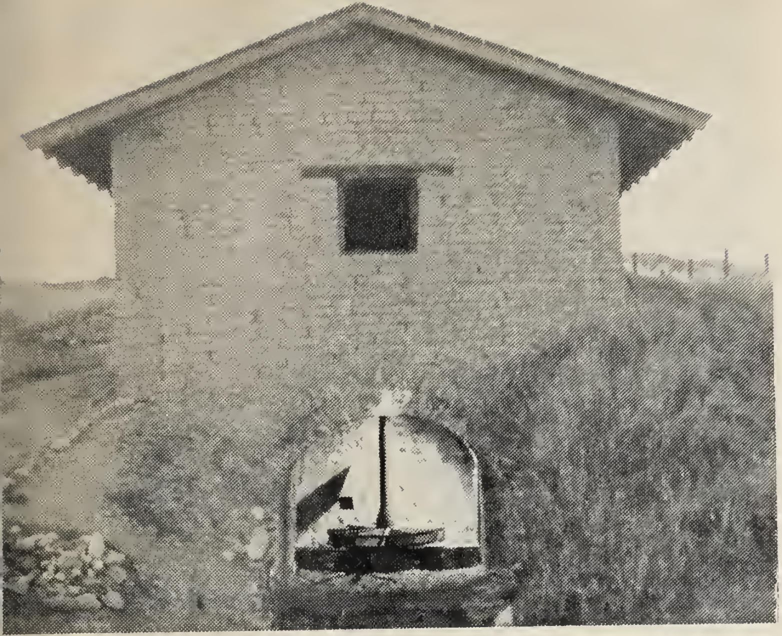
Hessian Fly formerly caused considerable damage in localized areas of California, but use of the resistant variety Big Club 43 has reduced the fly population to a level below economic importance. However, local outbreaks on both wheat and barley may occur. The flies lay their eggs on the upper surface of the leaves of young plants. The eggs hatch in three to 12 days, the small red larvae make their way down the leaf and behind the sheath, where they feed on the tender plant tissues. The larvae are full grown in two to four weeks. At that time they are glistening white, but soon turn brown, forming "flaxseed" or purporia. Adults emerge from overwintering "flaxseeds" in early spring to lay their eggs. Small plant tillers die, jointed tillers often break over and fall to the ground before harvest. Adults emerging from "flaxseeds" in stubble reinfest early fall-seeded fields. In addition to resistant varieties, the most practical control methods are complete plowing under of crop residues in the fall as soon as possible and maintaining a high level of fertility.

Wireworms—These small, yellowish or brown worms, about one inch long, are the immature stages of the click beetles. They feed on seeded grain and the underground parts of the plant, thus thinning stands. Treating the seed with lindane or aldrine before planting has been fairly effective in reducing damage. Such treatment should be combined with a fungicide for a combination pest and disease protection measure. *Since these chemicals are poisonous, treated seed should not be used for feed or food.*

Aphids—Aphid populations may, on occasion, build up to a point where they damage the plants. Under such conditions, chemical control may be economically feasible. Consult your local University of California Farm Advisor for current recommended control methods.

TWO CENTURIES OF WHEAT IN CALIFORNIA

Wheat was first sown in California about 1770, in the lower valley of the San Diego River near the original San Diego Mission settlement at Old Town. Until the discovery of gold, enough was planted annually around the expanding mission system to maintain mission personnel and to feed the military garrisons and some of the natives. The padres brought to California several wheat varieties, in-



Old grist mill, Mission San Antonio (Est. 1771) near Jolon, California.

Falling water, from a stone flume at rear of the building, drove the water wheel shown in the first picture above. This provided the power to turn the grist mill in the building constructed over the waterway. The second picture shows the grinding facilities. (Pictures by Dan Irving)

cluding Propo, Little Club, and Sonora. Also introduced at that time were such weeds as wild oats, filaree and mustard which probably came to California from Spain in contaminated wheat seed.

The mission wheat fields suffered from rust, and the padres had our current usual difficulties with birds and rodents. Yields therefore were generally not high. By 1821 statewide production had risen to 120,000 bushels a year.

Following the Mexican revolution, the early California settlers found wheat a good crop to grow. Within 10 years from the time John Sutter settled at New Helvetia, wheat was grown on farms scattered as far north as Cottonwood Creek.

Wheat production practices during the early American period were little advanced from those of the Spanish and Mexican days. The American plow and some other American farm implements had been brought in by 1850, but the crudest methods were still used. Harvesting was done with sickles, butcher knives, and bare hands; threshing by trampling

wild horses; and winnowing by throwing high into the air shovelfuls of grain, straw, and chaff, letting the wind blow away the lighter materials.

The pyramiding demand for food in California that followed the gold rush resulted in the great era of wheat during the fifties through the nineties. California was prominent in wheat production by 1859, only ten years after the gold rush began. Large areas well suited to wheat, together with the rapid development of farm machinery, particularly gang plows and headers, favored large-scale production; by 1888, the peak year, California ranked second in the nation for wheat, producing more than 42,000,000 bushels on 3,000,000 acres.

Until the sixties, the wheat growing possibilities of the more arid San Joaquin Valley south of San Joaquin County were not fully appreciated, and it was not until more than 20 years later that this crop was grown extensively south of Merced County.

Beginning about 1890 the California wheat acreage began to decline. Loss of a portion of the foreign market and inroads of bunt, rust, other diseases, and insect pests such as Hessian fly all contributed to this reduction. By 1906, wheat production had fallen to 790,000 acres. Between 1906 and 1956 the acreage fluctuated between about 500,000 acres and 1,000,000 acres, averaging somewhat less than 750,000 acres. Since 1956 it has dropped further. In 1960 there were 352,000 acres of wheat harvested in California, about one-third of it in San Luis Obispo County.

Two of the major factors in this decline have been the development of former wheat land into irrigated crop land, and the expansion of acreage devoted to barley. Barley has consistently proven more profitable for most dry-farming areas than wheat. Recent stringent government wheat acreage control programs have also been instrumental in reducing California wheat acreage. Any person considering growing wheat should first check with his local USDA Agricultural Conservation Program Service representative or with his University of California Farm Advisor concerning current regulations.

WHEAT ECONOMICS

A wheat enterprise, where rotation with more intensive crops is not possible, has to be on a fairly large scale. Dryland fallow wheat farming requires large acreages, as returns on an acre basis are usually low. A farm unit of 640 to 1,280 acres of land in crop each year requires a farm enterprise of at least 1,280 to 2,500 acres. To operate this many acres and perform such operations as short-period seeding—necessary in some years—requires heavy investment in large equipment. A 50 to 60 horsepower tractor, the necessary complementary tillage and seeding tools, plus a harvester, add up to a high investment for a family-size farm. Exclusive of land, in 1960 a California dryland wheat farmer, cropping about 1,200 acres of wheat annually, had about $65,000 invested in equipment. If he also owned his own land, his investment frequently totalled $250,000 or more. Harvesting for this size operation can be hired in most areas, though close supervision of custom operations is often advisable.

An investment in the size units outlined here points out the position of a specialized Western state wheat producing area when the trends of wheat consumption the past twenty to fifty years are considered.

The trend is downward for per-capita consumption of all flour and cereal

products, according to USDA reports. U. S. consumption slumped to about 142 pounds in 1958, from 193 in 1942 and 147 pounds as recently as 1955. The use of wheat flour alone dropped from 154 pounds per person in 1942 to 118 pounds in 1958; the drop in bread eating is largely responsible.

Farm economists see no end to the downward trend. Farmers, who eat more grain than their city cousins, make up a dwindling part of the population, less than 12 per cent today and probably no more than 7 per cent by 1975. Bigger paychecks encourage a shift away from bread and cereal and all so-called fattening foods.

But—for the California producer of high-quality wheat the outlook is good, if he will grow well the varieties wanted by the wheat trade. California millers want increased supplies of well-grown, weed-free, high-quality Ramona 50, Big Club 43 and Onas 53. Currently Californians are consuming about 50 million bushels of wheat annually, of which only about 8 to 10 million bushels come from California farms. California farmers can tap this burgeoning home market many times over their present level by producing high-quality wheat of the required varieties.

Wheat-growing districts will probably find it profiitable to concentrate on one or two well-adapted varieties. Once a miller locates a good quality wheat, he favors districts where he can purchase large quantities of that type.

Standardization and mechanization is the keynote of modern baking industry. The mills and bakers achieve it with a heterogeneous collection of wheats by blending, modifications in milling, variation in chemical treatment such as bleaching and oxidation, and use of adjuncts such as malt. The so-called strong wheats of the hard red classes seem necessary for blending with even the best California wheats; and since these apparently cannot be produced in quantity in California we must be content to produce the best possible white wheats.

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In order that the information in our publications may be more intelligible, it is sometimes necessary to use trade names of products and equipment rather than complicated descriptive or chemical identifications. In so doing, it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

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